THE LIFE AND WORKS OF RICHARD KIRWAN, PRES. R.I.A.

BY JOHN O'REARDON, ESQ. M.D.

A Historical Review of the Scientific, Philosophical and Literary Works of the late Richard Kirwan, Esq. F.R.S. L. *and* E. L.L.D. *and President of the Royal Irish Academy, with a brief notice of his Life.*

While the achievements of the warrior, and the services of the statesman, are recorded by the eloquent pen of the historian or of the poet, we ought not to withhold our meed of gratitude from that learned man who, by his useful labours, contributed more perhaps than any other individual to elevate the character of his country, and to promote the advancement of science, letters, and even arts, in the last and the commencement of the present century. His works, it is true, remain after him as so many faithful monuments of his ability and industry: they are, however, so numerous and so varied, that it may not be deemed uninteresting to give a concise account of each of them, as well as of the author. I had long hoped and expected that some person better qualified than myself would engage in this task; but seeing that it has been hitherto neglected, I have undertaken it rather than suffer the subject to fall into oblivion. My principal object is to present a succinct historical review of the scientific, philosophical, and literary productions of our illustrious countryman, the late Richard Kirwan, Esq. of Dublin, in which I follow the order of time wherein they were respectively published—save where the nature of the subject and the necessary connexion between productions of a similar nature may require a deviation from this arrangement; and to add somewhat to the interest of this essay, I shall occasionally introduce a few remarks respecting the more recent state of the scientific matters treated of by Mr. Kirwan. With respect to this gentleman's private life, I do not enter into much minuteness of detail. It was that of a virtuous, studious, and consequently retired man, and may be almost sufficiently understood from the number and tenor of his writings.

The subject of this essay was a native of the county of Galway, and inherited the fortune and respectability of his ancestors of the house of Kirwan, of Cregg, to which he added lustre by his personal worth and highly-cultivated mind and talents. Having first received a classical education in his own country, he was sent to the college of Poictiers in France. He there pursued the customary university course, and contracted an early habit of regular and solid study under the guidance of the Jesuits, who then ranked deservedly high as schoolmen and instructors of youth. Their pupil was afterwards not unfrequently heard to express himself in grateful terms of their attention to his health, his morals, and his general education. After a few years sojourn at Poictiers, Richard Kirwan received tidings of the untimely fate of an elder brother who was killed in a rencontre with the then speaker of the Irish House of Commons. The quarrel was caused by the brother's unauthorised intrusion into the body of the house, and by the poignancy of the public reproof then inflicted on him by the speaker. They met next morning and fought with small swords: poor Kirwan was an accomplished fencer, though he fell under the prompt thrust of an inexperienced antagonist.

Richard Kirwan having thus become the eldest surviving member of the family, came home to arrange his domestic concerns, and to enter

into possession of his estate. His next step was to qualify himself for the bar, to accomplish which, it was necessary to submit to the ordeal of abjuring the faith of his ancestors. The ambition of youth, and the desire of preserving his property from the confiscation then sanctioned by bad laws, led to the disavowal of his primitive religion. By this act he gratified the state, which required no more; but he became no convert to the state religion. As often afterwards as any mention happened to be made in his presence of the formulary used in the declaration or oath of recantation, he always spoke of it in terms of contemptuous sarcasm.* Whatever were his own peculiar theological opinions, his liberal mind reprobated the barbarous practice of offering violence to conscience, and of sanctioning by unhallowed oaths the calumnious vituperation of the venerable religion of many millions of intelligent fellow-countrymen, and of the majority of Christendom.

Mr. Kirwan practised for a few years as a lawyer, with what success I am not informed. It is certain that, however ambitious he might at first have been of the forensic robe and peruke, he did not continue long enamoured with his new profession. He soon began to find fault with the chicanery of the courts; his predilection for the natural sciences, and his increasing disrelish for the bar prompted him to exchange the vocations of the one for the more liberal study of the other. He repaired in consequence to Paris, and sojourned there long enough to apply to his favourite pursuits, and profit by the opportunities afforded in that great metropolis. That he also travelled to Germany may be considered probable, as he was well versed in the German language, and in the scientific books and system of mining of that country.

After his return a second time from the Continent, he resided during many years in London, among the English philosophers, with most of whom he formed an intimate friendship, that redounded to the mutual credit of all parties, and yielded only to the common catastrophe of mankind. Having by his writings acquired distinction at the meetings of the Royal Society, he was complimented by that learned body with the Copley-Medal, about the year 1781-2. I am informed that, during his abode in the British metropolis, his house was open, (like that of Sir Joseph Banks, the late dignified president of the Royal Society,) on stated days each week, for the reception of his colleagues and other gentlemen introduced by them.

He came back to settle in the capital of his native country, where he spent the remainder of his honourable career incessantly occupied in philosophical pursuits.

His mode of living was regular and simple; which contributed in no slight degree to his having preserved tolerably good health, and to his having attained an advanced age, notwithstanding the natural delicacy of his constitution. He rose at all seasons at five o'clock, said his morning prayers; then took a bowl of weak tea—studied till nine, or half past nine, when he breakfasted. He went out between ten and eleven, in case either business or pleasure induced him to do so; otherwise, he resumed his studies, and continued them till two o'clock, when he was visible for those who desired to speak with him. He

* Mr. Kirwan was educated abroad for the roman catholic priesthood; if on his return he pretended to conform to the protestant religion when in reality he did not, he must have gone up to the altar of God with a lie in his right hand, and committed a great crime. For his memory's sake, and his soul's sake, we hope this heavy imputation is not true.—Ed.

soon afterwards returned to his occupations until half past four—his dinner hour; he dined alone. From half past five to half after seven or eight o'clock was the time habitually allotted by him for his evening conversation parties, which, notwithstanding the earliness of the hour, were frequented by as many as he was willing to encourage. He partook of tea or coffee in company with his friends, and kept up a highly interesting conversation that was always suitable to the capacities and characters of those about him; he retired to his bed-room at eight o'clock, and, as it is said, never omitted concluding the day, as he began it, in fervent prayer to his Creator. He devoted the greater part of every Sunday to the study of holy scripture, and of ecclesiastical history. So serious was his admiration of the sacred writings, and his adoration of the divinity was so profound, that he bore the most unequivocal antipathy to those reputed to be either deists or atheists. On this principle, it was, that he often branded two noted continental writers of the last century with the epithet of infamous, in place of great, which their admirers affixed to their names. He at the same time had not the slightest idea of detracting from the transcendant literary merit which particularly distinguished one of these philosophers.

Mr. Kirwan had a fever in Paris at the age of twenty-four, and on its termination he became afflicted with dysphagia, which incommoded him much during the greater part of the remainder of his life. It was commonly attended with convulsive motions of the throat and face during the act of taking any solid aliment, though it did not impede the swallowing of liquids. He therefore abstained from the use of substantial diet, especially of animal food; until it was represented to him at a medical consultation, that his malady seemed to be in a great degree nervous, and that in addition to other means then directed, it was advisable to try the effect of forcing the obstacle. Having concurred in the latter opinion, he had recourse to ham, which agreed with him pretty well, probably in consequence of its being salt, dry, and stimulating: and it continued from henceforth to be his favourite meat. He took some bread with it, and diluted them with milk. He also occasionally eat spiced meats—and was fond of salmon. The use of milk at dinner was discontinued after some years; and in its stead was substituted water, which he generally drank in its purity, but on a few occasions he added to it a small portion of wine. As he did not consider the latter beverage necessary, he seldom took it undiluted, unless he happened to be ordered by his physician to do so, to obviate debility. His complaint was not unfrequently aggravated by his sedentary habits; and on the other hand, it was as often relieved by riding in the country. It diminished considerably in proportion as old age advanced; and it only rarely affected him to any inconvenient degree during the last two years of his life. However, he became latterly so delicate, that he seldom went out, otherwise than in his carriage. He seldom resorted to any public places, with the exception of scientific and literary societies, where his presence was always deemed a valuable acquisition. He devoted the entire of his time to his books and papers, and to his experiments in chemistry, mineralogy, and other branches of natural philosophy: and he persevered to the end in adding to his stock of knowledge, as well as in communicating it to the public in his writings. He was master of the classic languages, as well as of most of the living tongues of Europe. So retentive was his memory, and so regularly did he note down the heads of what he acquired by reading, practice and observation, that he was deeply versed in almost

every subject, and might have been considered as presenting in his own person a living Encyclopedia.

He made tours through most parts of Ireland, for the purpose of gratifying his curiosity, and extending his information with regard to mineralogy and geology. During some of his excursions for these purposes, he was not unfrequently amused by the remarks of the lower orders of the country people, who could scarcely conceive that any man of a rational mind could devote so much time as he did to the examination of rocks, of clay, and quarries, and to exploring the construction of mountains.

He was very economical in his personal and domestic expenditure, in consequence of his mode of living; which, from choice as well as from constitutional motives, was simple and plain. He however gave on various occasions, proofs of the kindness and liberality of his disposition. It is reported of him, on good authority, that he often opened his purse to relieve the necessities of merit in distress, and that lettered or scientific men in reduced circumstances, needed only to be made known to him to have their wants supplied or at least alleviated. He was an indulgent landlord, and so anxious was he to secure the welfare of his tenants, that when he perceived himself declining into the vale of years, he visited them, took up their old leases, and gave them renewals of their lands on the same easy terms on which they previously held them. His agent became embarrassed, and got in his debt to the amount of seven thousand pounds, which Mr. Kirwan generously forgave him, and notwithstanding so considerable a loss, he would have still permitted him to continue in office, if sufficient security could have been given of future punctuality in the collection and payment of his rents.

Mr. Kirwan became emaciated and weak during the last eighteen months, or two years of his life. His memory respecting recent occurrences, was perceptibly impaired, though his early recollections retained their wonted accuracy. His temper was also observed to be changed in his domestic circle. So sensible was he of the alteration in himself, that he was more than once heard to predict the approach of his dissolution. He got his last illness in consequence of an indigestion occasioned by eating an ill-baked apple dumpling. He felt it crude and heavy on his stomach. There supervened a low nervous fever, which he undertook at first to treat himself. But the disease having soon assumed a serious character, two learned physicians were called in to attend him. Death, however, could not be arrested. It closed the scene on the first of June 1812, in the seventy-ninth year of his age. It is almost superfluous to relate that his demise was universally lamented, not only by those connected with him in ties of consanguinity, but by every friend to science, and by every person capable of appreciating private as well as public worth. His obsequies were attended by a numerous train of mourning fellow-citizens who went in procession to tender their last sad homage to the mortal remains of their illustrious countryman.

His wife, descended from an ancient family of the Blakes of Galway, died many years before him, and left two daughters, who, as was to be expected, received the best education. One of these ladies married Lord Trimleston: the other became the wife of Colonel Hill.

Those who were acquainted with Mr. Kirwan must also have known the expert assistant of his numerous experiments, Samuel Wharmby, a native of London. This confidential and meritorious man, to

whom a competence was bequeathed for himself and for his family, survived his benefactor only a few months. He laboured under a bodily complaint, which, I have reason to think, would not have proved fatal so soon, were it not that the more refined part of his being, his spirit—his moral feeling, was bowed down by the force of sympathy, in consequence of the loss of such a friend and patron; with whom he was familiarised during forty years by a continual interchange of fidelity and protection, of attention and kindness, of veneration and esteem: a friend whose character and rank in life added considerably to the credit of his household. The world, obdurate though it may appear to be, furnishes some examples of similar effects of moral sympathy and human sorrow.

The earliest of Mr. Kirwan's works, that I have been able to discover, are chemical papers contained in the Philosophical Transactions of the Royal Society of London for the years 1780 and 82, consisting of "Experiments and observations on the specific gravities and attractive powers of various saline substances." He therein successfully directed his attention to ascertain the various degrees of force of chemical attraction, by which one body acts on different other bodies or even on the same body in various circumstances. His experiments and reasoning on this, as well as on other points, are truly original, instructive, and profound, for the time in which they were undertaken. But they are all too much clogged by the exploded theory and nomenclature of the old school, to be generally read with the attention which, in other respects, they merit. Besides, our author afterwards resumed the consideration of saline substances in a more correct and scientific manner, without any reference to phlogiston. In his dissertation on phlogiston, he exemplified, and at the same time modified, the doctrine of Stahl, which he saw attacked by the new theory then rising into notice. His treatise on this subject, while it maintains, with Stahl, that phlogiston is the general principle of inflammability in combustible bodies, and of malleability and splendor in metals, asserts that light inflammable air and phlogiston are the same substance, which assumes an æriform or a concrete state in proportion as it is charged with or deprived of elementary fire; that phlogiston, in the form of inflammable air, is separated by acids from metallic earths, which is accounted for on the score of double decomposition; that water is formed by the union of inflammable air and dephlogisticated air, only when one or both are exposed to a red heat, but that in a lower heat they constitute fixed air; that fixed air is the principle of acidity, which with an additional portion of phlogiston enters into the constitution of all acids; that the inflammable air obtained during the solution of metals in diluted acids, proceeds solely from the metal and not from the water. "Metals," says the author, "afford inflammable air, and consequently contain phlogiston. They lose parts of this in the process of calcination, and therefore fixed air must be produced during combustion by the union of inflammable air and the dephlogisticated part of common air, which after this union is absorbed by the calx. It is true that the mercurial calx and also the calces of lead and many others yield dephlogisticated air; but then the mercury is always revived, so that it is evident it re-takes the phlogiston from the fixed air, of which nothing then remains but the dephlogisticated part which accordingly appears in the form of dephlogisticated air." This reasoning, though it be since known to be erroneous, was then favourably received by the majority of the chemists of Europe, who

did not rightly understand the oxidation of metals and the decomposition of water. Soon, however, after its publication, its sections were respectively examined by six of the leading chemists of France, who brought to bear against our author inferences deduced from accurate experiments and facts; of which the sum is well known to amount to this:—that combustion depends on the attraction of the combustible bodies for oxygen; that the formation of acids is owing to the union of oxygene with the salifiable base; that metals become oxides by combining with oxygene, and that during their calcination they acquire an increase of weight exactly proportioned to the quantity of oxygen which they absorb; that hydrogene gas is not extracted from any metal, but proceeds from the decomposition of water; that carbonic acid consists of carbon and oxygen, and not of hydrogen and oxygen; and that it is in itself a distinct acid. The arguments of these philosophers were so demonstrative as to impress conviction even upon the mind of their ingenious rival. The cause of truth is advanced in science (as in politics) by the patient investigations and calm deductions of a combination of philosophical minds.

Mr. Kirwan, in his controversy with Mr. Cavendish relative to this chemist's "Experiments on air," was (as in his essay on phlogiston) on the wrong side of the question, in consequence of the obscure theory of his time, about what was termed the phlogistication of common air. The subject, however, ceased henceforward to be a matter of dispute. The cloud which enveloped it was dissipated, and our author was too frank and too enlightened not to yield the palm on this occasion to the illustrious discoverer of the component parts of water and of nitrous acid.

It was about this period that chemistry began to assume the dignity of a science. Doctor Black led the way by bringing carbonic acid gas to light. Cavendish and Priestley, who immediately followed, were the most successful enquirers of their day into the secrets of nature. The French chemists powerfully promoted the same object; and though they furnished fewer important original discoveries than the British, we are indebted to them for having superseded a most erroneous doctrine founded on a fictitious principle, and having substituted in its place a felicitous theory which set off and connected these discoveries, and facilitated the making of new ones. The latter were foremost in point of orderly distribution, of a satisfactory system, and of precision of nomenclature.

Notwithstanding the immense improvements made in chemistry within these last thirty years, and the state approaching to perfection at which it has arrived, the Lavoisierian theory, being for the most part founded on facts and in accordance with nature, continues predominant. It is the principal foundation of, or key to, the knowledge of this science. The general law established by Lavoisier in 1779, viz:—that "in every case of combustion, oxygen combines with the burning body," is still the chief leading rule of chemistry—save a few exceptions; and oxygen is acknowledged to be the acidifying principle of most or nearly all acids. Thus of all the known acids consisting of combustible bases and a supporter of combustion, four fifths are ascertained to contain no other supporter than oxygen; and the remainder are formed by the combination of combustibles with chlorine, iodine, and fluorine. With regard even to the nature and properties of chlorine or oxymuriatic acid, which have been held forth as the principal objections to the generalization or almost universality of

the agency of oxygen as a supporter of combustion; it is on most hands allowed that they are as explicable, or perhaps more so, by the Lavoiserian theory, as by the more recent views of Sir Humphry Davy.

Oxygen is the only alimenter of respiration. It forms a fifth part of the atmospheric air, and eight-ninths of the waters of the globe; and with the various metals it constitutes alkalies, earths, and metallic oxides.

Mr. Kirwan's "remarks on the specific gravities, taken at different degrees of heat, and an easy method of reducing them to a common standard," were next laid before the Royal Society.

Having taken his seat in the Royal Irish Academy, of which he was one of the founders, he presented to that assembly in 1789 his "Experiments on the alkaline substances used in bleaching, and on the colouring attractive matter of linen-yarn." With a view to public utility, he gives on this occasion a masterly analysis of crude mineral and vegetable alkalies. After having detailed the process for obtaining potash, he states "that in general, weeds yield much more ashes, and their ashes much more salts than woods; and consequently, that with regard to potash, neither America, Trieste, nor the northern countries of Europe, possess any advantage over us: that of all weeds fumitory produces most salt, and next to it wormwood." In addition to his own experiments on this alkali, our author derived no small share of information from a French treatise, entitled "L' art de fabriquer le Salin et la Potasse," which was published in 1779, by the directors of the saltpetre and gunpowder works in Paris. The same subject has been taken up and improved upon by others since the publication of Mr. Kirwan's tract; and it appears demonstrated that the leaves of trees furnish more ashes than the branches, and these more than the trunks; and finally, that the quantity of potash procured from a given weight of herbs or weeds, incinerated at the period of the maturity of their vegetation, is to that obtained from the same weight of grown forest timber, as eight is to one.* Truly satisfactory results! which are well calculated to afford encouragement to our national manufacturers in the fabrication of this alkali.

In the same year (1789) Mr. Kirwan communicated to the Irish Academy his "Observations on Coalmines," consisting—first, of general philosophical remarks regarding the interior construction of mountains, hills, and plains—secondly, of excellent practical directions relative to the discovery and working of coal-mines, and to convey a clear idea of the strata of earth or stone that commonly accompany coal-mines, he adds an account of those that are found in the principal mines of this description, in Europe.

His "Essay on the composition and proportion of carbon in bitumens and mineral coals," read before the academy a few years afterwards, is interesting both to the naturalist and practical economist.

One of our author's best works—that to which he devoted the most persevering attention, and which may be considered more peculiarly his own—is his series of "Experiments and Observations on the Strength of Acids, and the proportion of ingredients in neutral salts and other compounds."† The determination of the quantity of standard or real acid in mineral acids of different densities at given temperatures,

* See the experiments of MM. Pertuis and Sage, annexed to a subsequent edition of "L' Art de fabriquer le Salin et la Potasse."

† Almost all Mr. Kirwan's results respecting acids are since overthrown by Drs. Ure and Thomson.—Ed.

was never before attempted by any person. And the estimate of the proportion of the component parts in neutral salts was only undertaken by a few, the results of whose researches were different. But in proof of our author's accuracy, it is to be observed that his conclusions—in particular those of his latter memoirs on that subject—coincide pretty nearly with the mean of those of the most celebrated chemists,* such as Cavendish, Berthollet, and Woulfe—to which may be added, the more modern trials of Mr. Chenevix. The precision of Mr. Kirwan's experiments and calculations on a matter of such nicety, is admirable, if we allow for the imperfect condition in which chemical science existed previously to his time. It evinces an investigating, acute mind—considerable analytical skill, seconded by a knowledge of mathematics and logic, and an extensive general education. Like a man of a superior mind, he frankly acknowledged some mistakes committed in his first essays, and profited by the judicious remarks passed on them by Messrs. Berthollet and Guiton Morveau. The subject occupied his attention at different periods during seventeen years. But to form an adequate idea of his experiments and train of reasoning, and derive from them the principal information which they afford, it is sufficient to read the three last memoirs published on that topic in the Irish Transactions from the year 1789 to 1797.†

The Transactions of the Royal Irish Academy for 1793, contain four separate papers from the president; one of which is a "Comparative View of Meteorological Observations made in Ireland during the five preceding years, with some hints towards forming prognostics of the weather."

The next presents the "State of the weather in Dublin from the first of June, 1791, to the first of January, 1793." In the third paper are given the author's "Reflections on Meteorological Tables."

The fourth paper consists of "Examinations of the supposed igneous origin of stony substances," in which he very forcibly urges his objections to Hutton's ingenious system.

The succeeding volume of the Irish Transactions contains his "Essay on Manures," which was written in answer to the following judicious question proposed by the academy: "What are the manures most advantageously applicable to the various sorts of soil, and what are the causes of their beneficial effects in each particular instance?" The same essay was afterwards re-published with improvements and additions, in the Transactions of the Dublin Society in 1801. The first chapter of this essay explains the nature of the different soils known in agriculture, whose general utility has been ascertained by

* None of Mr. Kirwan's estimates of atomic weight are now deemed correct.—Ed.

† The doctrine of chemical proportions continued to advance since the publication of the above memoirs; and for the state of accuracy at which it is now arrived we are in a great degree indebted to the late learned and ingenious Doctor Hyde Wollaston, who availed himself of more recent discoveries, in a paper read by him to the Royal Society in November, 1813, where he describes an instrument invented by himself for exhibiting at one view an epitome of what he terms "Chemical equivalents. This instrument is formed of paper with a moveable graduated slide, like that of the sliding rule—presenting the names with the elementary principles or component parts of all the acids arranged in the order of their relations to each other, and to their respective bases—stating the relative quantity by weight of their contents of oxygen, hydrogen, azote, base, and water; and including the definite proportions of the integral atoms of the most important compounds. This method abridges the labour of the analytical chemist, and presents a correct and summary view of chemical bodies.

long experience. In the second chapter, an inquiry is entered upon regarding such of these manures as are most profitably applicable to each particular soil, and about the causes of their beneficial effects in each particular instance. Chapter the third, indicates the mode of ascertaining the composition of a soil. The fourth part, being the last, is a continuation of the subject of the second chapter. This work, rich in valuable information, should be studied by every well educated country gentleman, and by every chemist who is endowed with a taste for the cultivation of land: it evinces the advantage of the application of chemical knowledge to agriculture. The same subject was previously examined by Earl Dundonald who, in his treatise on the connexion of chemistry with agriculture, gave proof of greater proficiency in the latter department, but of less in the former, than our author. It also occupied the pen of Mr. Young; and was subsequently benefited by Dr. William Meade's analysis of several species of calcareous manures of the county of Cork, published in the fifth volume of the Transactions of the Dublin Society. It lately received considerable illustration and improvement from Sir Humphry Davy's "Elements of Agricultural Chemistry," an important, experimental and scientific work.

Mr. Kirwan presented to the academy an accurate account of strontianite, so early as January, 1794; not probably having been then aware that a similar analysis of the same mineral had been performed a few months before in Edinburgh, by Doctor Hope, and in Berlin by M. Klaproth. His mineralogy, of which the second edition was published in 1795, treats of earths and stones in the first volume, and of salts, and inflammable and metallic substances in the second volume. He acknowledges the advantage which he enjoyed on this occasion, in the use of that rich collection of fossils, the Leskean cabinet, brought in consequence of his recommendation from Germany to Ireland, and deposited in the museum of the Dublin Society, where he, in his turn, benefited it by an exact determination of the specific gravity of many of its specimens, and their fusibility in various degrees of heat; and as his work frequently refers to the marks and numbers of that cabinet, it is, therefore, somewhat better calculated for mineralogical students in Dublin, than elsewhere.* His genera and species are, for the most part, distributed according to chemical classification. His description of each mineral comprises an enumeration of the external characters taken with very little variation from Werner: namely, "colour, shape, lustre, transparency, texture, cohesion, density, adhesion to the tongue or fingers, general feel, absorption or diffusion in water, smell and taste," to which he adds the internal properties, such as "their magnetic and electric qualities, and sometimes their phosphorescence, their relation to acids, to fluxes, and to fire; and lastly, the results of a just analysis." He suggests a few improvements in the descriptions of the external characters, by denoting the degrees of intensity of some particular qualities by figures. He introduces some new genera and species. The tables of the fusibility of the simple earths, mixed in various proportions in heats not exceeding 166° of Wedgewood, being the result of many laborious and precise experiments, are highly instructive and applicable to the improvement of

* The Leskean Cabinet contains 7331 specimens, which are distributed conformably to the plan of the mineralogical school of Freyberg and that of M. Pabst Von Chain. Annexed to this collection, is a well-stored assortment of Irish and British minerals.

those arts in which such substances are employed. We read with much satisfaction in the same work, his account of volcanos collected from Dolomieu de Saussure, Hamilton, and others, and his own observations thereon, which are rational and luminous. He maintains, that lavas owe their liquidity to melted bitumen and sulphur: which hypothesis is objected to by many respectable geologists of the present day, though as yet we have but the single experiment of Sir James Hall in any degree satisfactory on this point, as tending to demonstrate the perfect fusion of lava in its recent state.* His distinctive characters of volcanic and neptunian mountains seem to be accurately drawn; he closes the subject by stating the reasons that impress conviction on his mind, that neither basalt nor trap are of volcanic origin; in doing which he at the same time ably meets the arguments urged in favour of the different modifications of the volcanic theory, and advances his own ingenious and well-supported reasoning in proof of the neptunian origin of basalt. The latter part of the first volume treats at large of the analysis of earths and stones; and the second volume also concludes with an essay and analysis of metallic ores; all of which are conducted with the learning of a scholar, joined to the accuracy of an experienced chemist. No other treatise of the kind that has hitherto appeared, should prevent us from reading these two volumes which constitute an excellent practical work, uniting, in a methodical satisfactory order, mineralogical, metallurgical, general chemical, and geological knowledge, and skilfully applying the same to the most serviceable national purposes. We are at the same time, perfectly aware that in conformity with the usual progress of the natural sciences, many new species and varieties have been discovered since the publication of this work; and we know how to appreciate duly the modern valuable writings on the subject, among which may be mentioned, as highly deserving of notice, Abbé Haüy's beautiful theory regarding the geometrical form and composition of crystals.† This theory was

* We fear that Sir H. Davy's discovery of the combustible bases of the earths is here forgotten.—Ed.

† The principal objections urged against the Abbe's theory, and which Mr. Kirwan was known to concur, are two, namely.—1. That the same primitive form is therein assigned to some minerals of different nature.—2. That the greater number of minerals are not crystallized, and that they therefore have no discoverable regularity of structure. In consequence of these objections, as also for the satisfaction of some who may not recollect, or may perhaps not be acquainted with this philosopher's theory, I shall digress a little to mention, in as few words as possible, what it consists in. Its leading feature is comprised in the consideration of the regular solids denominated the *primitive form* and *integral molecules* of crystals. It has been long remarked that a considerable number of minerals are composed of laminæ susceptible of being separated from one another. The anatomy or mechanical division of a crystal, suggested in consequence of this observation, is performed by detecting with a sharp instrument, such as the blade of a knife, the natural joints of its component plates; if we thus divide the different original crystals of the same substance by sections which correspond with each other on all the parts similarly situated, we succeed in extracting a regular solid called the *primitive form*; which is uniform and unalterable in every specimen of these crystals, even in those whose outward shape presents the greatest disparity. The *primitive form* then is, with respect to the same species, a solid of an invariable figure, often concealed under a symmetrical external envelope, and which may in all cases be reduced to its nucleus, either by mechanical division, or simply by reasoning and calculation. The primitive geometrical forms hitherto ascertained, are six in number, viz.—the parallelopiped; the octœdron with triangular faces; the regular tetrædron; the regular six-sided prism; the dode-cahædron terminated by equal and similar rhombs; the do-decahædron with isosceles triangular planes.

not favourably received by Mr. Kirwan, probably because he was never disposed to direct his mind seriously to the consideration of it; and it is undervalued in consequence of being misunderstood by the author of a recent mineralogical treatise of merit in our language.

Mr. Kirwan's work on mineralogy was soon followed by an "Essay on the Analysis of Mineral Waters," of which the plan is "to state, add to, and generalize the modern improvements in the chemical examination of these liquids, to propose new re-agents and new limitations of the re-agents already known, and to substitute more direct means of investigation to the random methods before employed." "These," as the author observes, "are considerations of importance in a medical point of view, and also for the purpose of detecting several valuable ores concealed in the depths of the earth." "The substances," says Mr. Kirwan, "hitherto discovered in mineral waters are either of the class of aërial fluids, or of an acid, alkaline, or earthy nature, or neu-

The integral molecule or integral particle, is the form resulting from the subdivision of the primitive form in an order parallel to its different faces, and sometimes in other directions. It is observed that there are only three of these elementary figures, namely; the triangular pyramid or the tetrædon; the triangular prism; and the parallelopiped, which give origin to all the different crystals of nature. The theory of the structure of crystals is founded on the primitive form of these bodies, on the mutual inclination of their corresponding planes, on the constancy of the angles of the bodies which belong to the same variety of crystallization, and on the integral particles. M. Haüy assumes the primitive form as the type of his species in preference to the integral particle, for this reason, that the first represents the immediate result of the mechanical division of a crystal, and at the same time the simplest product of crystallization, which is naturally presented to our view in many species. Such, however, is the mutual relation subsisting between these two forms, that one cannot be peculiar to any species of mineral without the other being so likewise. He endeavours to prove, (and does so as I think with success,) that the character furnished by the structure of crystals, is the only one which does not participate of the variations caused by the mixture of heterogenous matter, of which the influence modifies the hardness, the specific gravity, the fusibility and colour of bodies, and even the result of analysis.

The former of the objections above mentioned may be removed by considering, that similarity of structure, and identity of elementary composition are understood to unite to constitute the species.

With regard to the second objection, the following circumstances are to be attended to:—it is acknowledged that the application of the geometrical character is limited to crystallized substances, or to these substances which, without being properly crystallized, have a lamellated structure. The character in question indicates the first links only of these chains which form the species; but the other links are by no means neglected. The French mineralogist in his delineation of each species, places the crystallized substance, as the most perfect model, at the head of the series, to this belong and are attached the determinable varieties of that crystal depending on the same primitive form: next follow the varieties of irregular or indeterminable forms, in which from the confusion of the process of crystallization; the regular shape of the primitive form is supposed to have been destroyed, while the elementary composition remains unchanged. The amorphous or shapeless masses belonging to the species, are also noticed at the end of each respective series. His descriptions are not only geometrical, but they likewise include the physical and chemical characters of the species, which are treated as completely as the present state of the natural sciences admits of. His researches relative to the properties of double refraction, magnetism, and electrical susceptibility in minerals, are particularly interesting and novel. He conceives the aggregated primitive rocks to be the result of a tumultuous crystallization: but as he thinks that these, like clay marle and volcanic products, belong to geology rather than to mineralogy, they are disposed in appendixes. His treatises on this subject forms an epoch in the annals of philosophy. They have had the merit of raising mineralogy from the level of a descriptive art, to the dignity of a science.

tral or semineutral substances, or hepatic or saponaceous compounds, or extractive matter." He describes the nature and agency of the different tests of the gases, as well as of each of the acids and their bases. Next are introduced what he properly terms secondary tests, applicable to particular combinations of many acids and their bases. He does not omit to notice the incompatible salts, that is, those which decompose each other and cannot co-exist in the same solution, but in states very distant from the point of saturation. The specific gravity and other physical properties of mineral waters are also taken into account. He afterwards enters more closely into the subject of the analysis of these fluids; which comprehends three branches of inquiry—namely, first, the determination of the different species of salts; secondly, that of their quantity; lastly, the ascertaining the existence, species and quantity of gases. He conducts this three-fold investigation partly by tests, partly by evaporation; and the quantities of solid ingredients are in most instances determined by estimation founded principally on his own experiments, confirmed by those of other eminent analysts. The work concludes with an interesting paragraph on the depuration and augmentation of common salt contained in brine waters, and with another article on the employment of alcohol as a precipitant of some salts and as a solvent of others. This (with the exception of some of its terms—to wit, tartarian, volalkali, selenite, baroselenite, sylvian, and muriatic earth, which are nearly unintelligible,) is, according to my humble judgment the most complete and instructive volume of its kind in Europe. It is a classical test-book that is deserving of being translated into every language, and put into the hands of every chemist, by the side of the distinguished elementary works of a Lavoisier, a Fourcroy, and a Davy. It comprises in a small space a considerable and well-arranged mass of chemical knowledge, of which a good portion is in truth collected from various quarters, not by the hand of a mere compiler, but by a man of uncommon skill and erudition, whose information, personal experience, and ripe judgment enabled him to select materials from the most unexceptionable sources, and whose candour induced him to quote his authorities, both British, French, Swedish, German, and Italian. His own experiments, with which the work is enriched, are important and well conducted. Should a new edition of this book be prepared by some intelligent chemist, it would, in consequence of the progress which the science has made within these late years, admit of a few corrections, or rather additions—of which I may be permitted to adduce one or two examples. Our author, while on the subject of ascertaining by oxalic acid the presence of lime in a state of combination with a mineral acid, justly observes, that certain circumstances must be attended to; as, when the mineral acid abounds, and is in some measure disengaged from any combination, it either decomposes the oxalic acid or dissolves the oxalate of lime, if any be formed, and thus prevents either totally or partially the appearance of a precipitate, and it occurs principally when nitrate of lime is concerned. For this he gives no remedy further than to mention that Bergman was not able to obtain a precipitation of the entire of his oxalate of lime, until the liquor was evaporated; and he properly cautions us to purify our oxalic acid, by a second crystalization, from all remains of nitrous acid that may adhere to it at its first formation. But he omitted to notice (and it probably was not then known) that in such cases oxalate of ammonia is the surest reagent, since the ammonia combines with the mineral acid, and conse-

quently prevents the latter from decomposing the oxalic acid or dissolving the oxalate of lime.

With regard to potash and soda, he indicates in a satisfactory manner their distinctive characters by stating the different results of the combination of each of these alkalies with nitric, tartaric, and oxalic acids, and with the oxide of nickel. There are, however, some other criterions which he does not mention. 1. The vegetable alkali by itself, or in a state of combination with an acid, presents a yellow precipitate, consisting of a triple salt, with a solution of purified platina. Soda has not this effect; but it causes a deposition (if I mistake not) of the other metals alloyed with crude platina. There is still another method of distinguishing these alkalies, which, though seldom or never applicable in the analyses of mineral waters, may obtain a place here; potash, by exposure to the air, attracts water and carbonic acid, liquifies, and at length forms crystals of subcarbonate of potash. Soda in contact with the atmosphere also imbibes moisture and carbonic acid, and is reduced to a pulpous consistence, but it does not become liquid.*

In a paper read by Mr. Kirwan to the Academy in 1796, an attempt is made to prove some analogy between the laws of crystalization and those of magnetism, and a comparison is drawn between the repulsive and attractive power of the ultimate particles of crystals and that of the magnet.

In his "View of the weather" of the last mentioned year, read in the ensuing month of January, he mentions, among much other matter: "For some years past, I have remarked that a change of weather most commonly happens on the seventh, fourteenth, and twenty-first of every month—a day before or a day after: but sometimes, though rarely, the weather continues for three or four of these periods." It would appear rather too minute to dwell here on every one of his synoptical views of the state of the weather in Dublin, which were continued almost annually to his death.

Our countryman devoted considerable attention to meteorology, on which he wrote three elaborate essays. One of these was separately published, in an octavo volume, in 1787; another occupies thirty quarto pages of the Transactions of the Academy for 1788; and the third, amounting to two hundred and thirty-six quarto pages, was given in the Transactions of the same society in 1801. I think them sufficiently instructive and entertaining to warrant my giving a short account of each; but, as I have occupied the time of the reader perhaps too much already, and as the detail of these and the remaining life and works of Mr. Kirwan will afford ample matter for another paper, I shall here conclude for the present.

J. R.

* It would, we apprehend, be more accurate to say that having imbibed moisture and carbonic acid, it then crystallizes, and finally effloresces; and generally, we would observe that the chemical language in many parts of Dr. O'Reardon's review is accommodated rather to the periods at which Mr. Kirwan's works appeared, than to the present advanced state of chemical science, and very improved methods of analysis.—Ed.